Air Pollution Monitoring System

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ABSTRACT
The increasing concern over air pollution and its health impacts has necessitated the development of real-time, low-cost, and effective air quality monitoring systems. This project presents an Internet of Things (IoT)-based air pollution monitoring system using Arduino Uno R3 as the central microcontroller. The system integrates an LM35 temperature sensor and gas sensors MQ6 and MQ9 to detect and monitor concentrations of harmful gases such as carbon monoxide (CO), methane, LPG, and other combustible gases. The real-time data is displayed on a 16x2 LCD and transmitted to the cloud for remote monitoring using a Wi-Fi module (ESP8266). The system is equipped with alert mechanisms such as a buzzer and a relay-controlled AC bulb to warn users when pollutant levels exceed safe thresholds. This system aims to enhance public safety and environmental awareness through timely interventions.

Keywords: Arduino-based systems, Air Pollution Monitoring, Interfacing, Alerting Systems, Sensor Integration, Real-Time Data Acquisition, IoT-Based System, Wireless Data Transmission.

1. INTRODUCTION

Air pollution is one of the most pressing environmental challenges affecting the global population today. The rapid industrialization and urbanization in recent decades have significantly increased the concentration of harmful pollutants in the air, leading to adverse effects on human health and the ecosystem. Major pollutants such as carbon monoxide (CO), methane (CH_4), liquefied petroleum gas (LPG), and other combustible gases are often released from vehicles, industries, and domestic activities. These gases, when present in high concentrations, can cause respiratory issues, cardiovascular diseases, and in extreme cases, prove to be fatal. Therefore, there is a critical need for a reliable, cost-effective, and real-time system that can monitor air quality and alert individuals and authorities of hazardous conditions.

This paper presents an IoT-based air pollution monitoring system utilizing the Arduino Uno R3 microcontroller. The system is designed to detect and measure environmental parameters such as temperature and the concentration of various gases using an LM35 temperature sensor and two gas sensors: MQ6 and MQ9. The MQ9 sensor is capable of detecting gases such as carbon monoxide (CO), methane, and LPG, while the MQ6 sensor is specifically sensitive to flammable gases like butane, propane, and natural gases. These sensors provide analog output signals corresponding to the concentration levels of target gases in the surrounding environment.

The Arduino Uno collects data from the sensors and processes it to determine whether the concentration levels of gases exceed predefined safe thresholds. If any of the readings surpass these limits, the system triggers an alert mechanism, which includes activating a buzzer and switching on an AC bulb through a relay module. Additionally, a 16x2 LCD display is used to present real-time gas concentration and temperature values to users on-site.

For remote monitoring and data analysis, the system incorporates an ESP8266 Wi-Fi module, enabling the transmission of sensor data to a cloud platform such as Thing Speak or Firebase.

This integrated solution provides an efficient means of monitoring indoor and outdoor air quality in real time and ensures timely alerts and interventions. The system not only enhances personal and public safety but also contributes to environmental awareness and data-driven decision-making. Its low cost, portability, and scalability make it suitable for various applications in smart cities, industrial safety, and environmental health monitoring. The proposed system thereby offers a practical approach to mitigating the risks associated with air pollution and promoting healthier living conditions.

2. LITERATURE REVIEW

Air pollution has become a critical global concern due to rapid industrialization, urbanization, and the increased usage of fossil fuels. Various studies have been conducted to develop systems capable of monitoring and controlling air pollution using IoT technologies. This section reviews relevant research works and technologies to highlight the advancements and gaps in the field.

2.1 IoT in Environmental Monitoring

Several researchers have employed IoT technology in environmental monitoring due to its ability to provide real- time data acquisition, wireless communication, and remote- control capabilities. In [1], an IoT-based air quality monitoring system was implemented using NodeMCU and MQ135 gas sensors to measure CO2 and CO levels. However, the system was limited to basic alerting and lacked temperature monitoring and broader gas detection.

2.2 Gas Sensor Technologies

Gas sensors like MQ6 and MQ9 are widely used for detecting combustible and toxic gases. In [2], MQ9 was utilized for detecting CO and methane with notable sensitivity and stability. Similarly, MQ6 was highlighted in [3] for its capability to detect flammable gases including LPG and butane. Despite their individual effectiveness, integrating multiple sensors for improved **accuracy and broader** detection is still an area of development.

2.3 Real-Time Alert Mechanisms

The use of relays and actuators for alerting in critical conditions has been demonstrated in [5], where the system activated a buzzer and LED lights when gas levels exceeded set thresholds. However, limited automation and lack of integration with home appliances or systems like smart bulbs/ACs was noted.

3. EXISTING METHOD

Air pollution monitoring has gained significant attention in recent years due to rising health hazards and environmental degradation. Traditional methods of air quality measurement involve fixed monitoring stations equipped with high-end analyzers, which are often expensive, non-portable, and limited in coverage. These setups typically require manual data collection and analysis, which delays real-time response and limits their use in dense urban or rural areas.

3.1 Conventional Monitoring Systems

Most government-operated air monitoring stations use high- precision equipment like gas chromatographs and mass spectrometers to detect pollutant levels. These systems are highly accurate but come with major drawbacks:

3.2 Early Microcontroller-Based Systems

To address these limitations, researchers and developers began utilizing microcontroller-based solutions like Arduino and Raspberry Pi. These systems integrate basic sensors to monitor temperature, humidity, and gas concentration. For instance:

3.3 Alert Mechanism Limitations

Existing low-cost systems often only display readings via serial monitor or basic LCD without a robust alert mechanism. Few systems integrated actuators like buzzers, relays, or smart devices to act immediately upon detecting high pollution levels. Real-time user alerts and environmental intervention (e.g., switching off appliances or activating ventilation) were not effectively implemented.

3.4 Lack of Multi-Sensor Integration

Many earlier systems relied on a single gas sensor such as MQ135, which provides only a general air quality index without differentiating between specific gases like CO, CH4, or LPG. This compromises the ability to take targeted preventive action based on the specific pollutant detected.

4. PROPOSED SOLUTION

The proposed system addresses the limitations of conventional and early microcontroller-based air pollution monitoring methods by presenting an IoT-based real-time air quality monitoring and alert system. It combines the capabilities of embedded systems, sensor technology, and cloud computing to form a compact, cost-effective, and scalable environmental monitoring solution.

This system is designed using an Arduino UNO R3 microcontroller as its core processing unit and integrates multiple sensors to detect various environmental parameters. The temperature sensor (LM35) provides ambient thermal readings, while gas sensors (MQ6 and MQ9) detect the presence and concentration of flammable and toxic gases, including carbon monoxide (CO), methane (CH_4), liquefied petroleum gas (LPG), butane, and natural gas. The values collected are displayed locally on a 16x2 LCD screen, and alerts are provided via a buzzer and an AC bulb controlled through a relay module. For remote monitoring and data analytics, the system uses an ESP8266 Wi-Fi module to send data to a cloud platform.

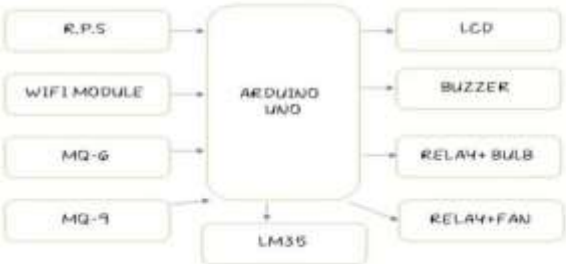
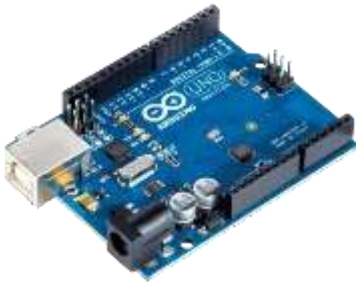


Fig.4.1.1: Block Diagram

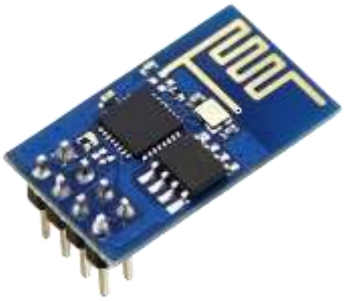
5. HARDWARE COMPONENTS

5.1 Arduino UNO



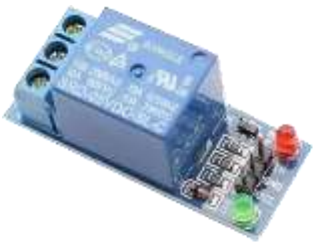
This is an open-source Microcontroller ATmega328P with a total of 28 pins but 20 pins can only be programmable divided into 14 Digital pins and 6 Analog pins. We are using ARDUIO IDE for programming with USB Cable.

5.2 WIFI Module

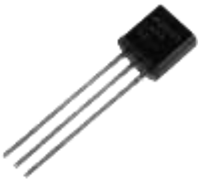


WIFI (wireless fidelity) module is a low-cost, compact, and versatile microcontroller module designed for wireless communication in IoT applications. It is based on the ESP8266 SOC (System on Chip) by Espressif Systems and supports Wi-Fi networking, making it suitable for connecting devices to the internet or local networks**.**

5.6 Relay

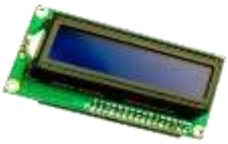


5.3 LM35 Temperature sensor



A sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. The output of the LM35 temperature sensor is in milli(mv). connect the VCC Pin to 5v and GND to GND, output of the LM35 temperature sensor is in the analog form, to It is a remote-controlled switch which can be controls automation by turning the system ON/OFF. It also protects from over loading situations.

5.7 LCD



LCD (liquid crystal display) is the technology used for displays in notebook and other smaller computers. Like light- emitting diode (LED) and gas- plasma technologies, LCDs allow displays to be much thinner than cathode ray tube (CRT) technology. LCDs consume much less power than LED and gas-display displays because they work on the principle of blocking light convert this into digital form we are going to use analog to digital converter.

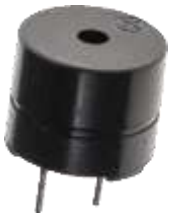
5.4 MQ6 Gas Sensor

It is used to detect various gases such as alcohol, benzene, carbon dioxide etc. This Sensor gives output in analog format. This Sensor operates on 5V supply. This Sensor can be used in buildings and offices.

5.5 MQ9 Gas Sensor

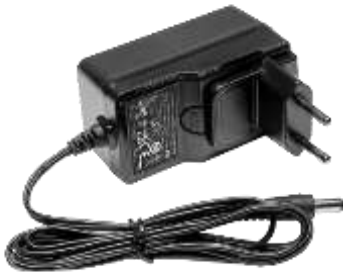
Methane sensors are gas detectors that measure ine concentration of a target gas by oxidizing or reducing the target gas at an electrode and measuring the resulting current. rather than emitting it.

5.8 Buzzer



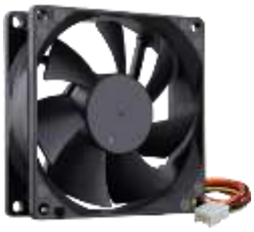
It generates sound by vibration of piezoelectric element by applying electricity. In our project we are using this as high alert indication for critical conditions.

5.9 Adapter



It's a 12V adapter used as a power supply which converts alternating current into direct current. We are connecting this from wall outlet.

5.10 CPU Fan

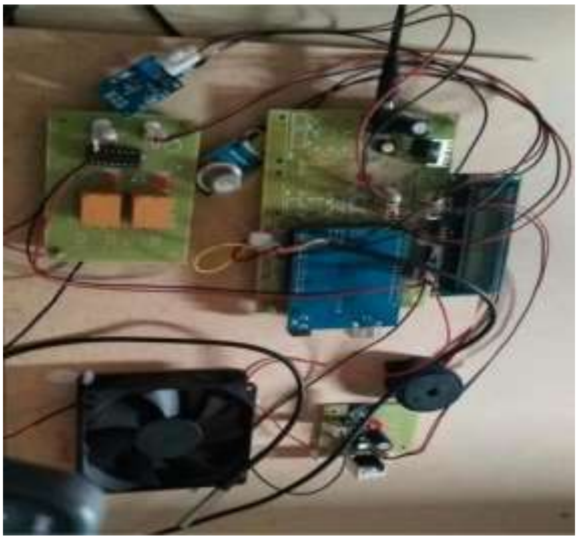


A DC motor which converts electrical energy into mechanical energy. In our project we using this component to represent the Fan present in the railway station.

6. SOFTWARE

6.1 Installation of ARDUINO

Step-1: Download And Extract Arduino IDE Software.



Step-2: Launch Arduino IDE, Open the Arduino IDE from the desktop icon click next to install then click on icon to open the software.

6.2 ARDUINO Code Dumping

Step-1: Open your first project.
Step-2: Select your Arduino board then, Go to Tools > Arduino nano Boards > Boards Manager.
Step-3: Select your Arduino board Processor then, Go to Tools > Processor > ATmega328P.
Step-4: Edit Code on Editor Window then, Click on File tab and then open preferences.
Step-5: Compile code.
Step-6: Upload Code into Arduino Board.

7. ADVANTAGES

7.1 Real-Time Monitoring and Alerts

Provides instant data and warnings to prevent health hazards and respond to pollution spikes quickly Improves Public Health

Helps reduce respiratory and cardiovascular diseases by informing people about air quality and encouraging safety measures.

7.2 Data for Policy Making

Supplies accurate and continuous air quality data for environmental planning, regulation enforcement, and urban development.

7.3 Automation and Control

Can be integrated with systems that control ventilation, air purifiers, and alarms to take automatic corrective actions.

8. APPLICATIONS

8.1 Indoor and Outdoor Air Quality Monitoring

S.No	Temperature	Mq6	Mq9	Date
1	32	117	28	2024-12-20 12:46:42
2	34	27	31	2024-12-20 12:46:06
3	46	27	27	2024-12-20 12:45:00
4	42	29	28	2024-12-20 12:44:39
5	33	41	214	2024-12-20 11:35:15
6	28	29	25	2024-12-18 15:11:15

Ensures healthy air in homes, offices, hospitals, and schools by detecting pollutants and triggering air purifiers or alarms.

Helps governments and organizations monitor pollution levels in cities, towns, and public places for better urban planning

8.2 Industrial Emission Monitoring

Tracks air quality around factories to comply with environmental regulations and reduce harmful emissions.

8.3 Road side Pollution Monitoring

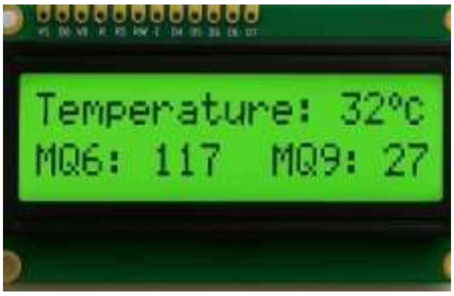
Installed near roads to analyze vehicle emissions and guide traffic management policies.

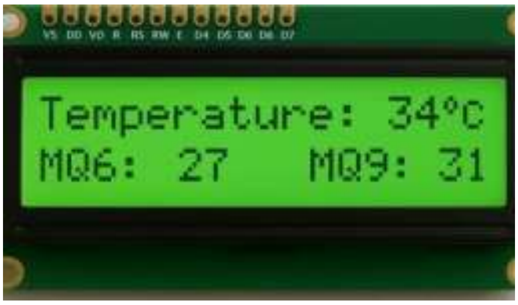
8.4 Airport Air Quality Monitoring

Monitors emissions from aircraft and ground vehicles to maintain safe breathing environments for workers and passengers

9. EXPERIMENTAL RESULTS

The result obtained after completion the project is whenever the persons detected by the sensors, then it shows notification on Lcd and send the messages to a cloud platform such as Thing Speak using Wifi module as well. The thing that will be most helpful is high alert using buzzer in critical situations.





10. FUTURE SCOPE

The primary objective of this system is to monitor and check air quality and keep it under control for a better future and healthy living for all. The system proposed here also monitors sound pollution in particular areas so that authorities can act against it.This system is intended to continuously collect data on air quality and noise levels using sensors, analyze the data using a microcontroller, and send the data to an online platform for display and alert purposes.

Integration with Cloud and Big Data Analytics

Future systems can store and analyze large volumes of pollution data using cloud platforms. Big Data and AI can identify pollution trends, predict future pollution levels, and provide insights for decision-making.

Advanced Sensors for More Parameters

Future versions can include sensors for PM2.5, PM10, CO_2, SO_2, and O_3 to give a more complete air quality index (AQI).Integration with UV and radiation sensors can enhance environmental monitoring further

Use of Drones for Aerial Monitoring

Drones equipped with pollution sensors can cover larger areas and reach places that are hard to monitor from the ground. Useful for forest fire detection, construction sites, and industrial zones.

Smart City Applications

When integrated with smart city infrastructure, the system can automatically control traffic or industrial activity based on pollution levels. It can guide urban planning by identifying pollution hotspots and helping in zoning and development planning

CONCLUSION

The Air Pollution Monitoring System based on IoT technology provides an efficient and cost-effective way to monitor the environment in real-time. This system successfully integrates various sensors—such as temperature, humidity, gas, and sound sensors—to continuously track environmental conditions and detect pollution levels. The collected data is processed by a microcontroller and communicated to users through messages, ensuring timely alerts and awareness. The main advantage of this system lies in its ability to provide remote access to critical environmental information, allowing individuals, communities, and authorities to take immediate action in response to pollution hazards. This not only helps in reducing health risks but also plays a vital role in maintaining ecological balance and supporting smart city initiatives. By implementing such a system, we take a significant step towards creating a sustainable and healthier environment, where technology aids in the early detection and prevention of environmental degradation. This project also demonstrates how IoT can be effectively applied in real- life scenarios for environmental monitoring and public safety.

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